REMARKS

A. Objection to the Specification

In paragraph (1) of the Office Action of September 22, 2004, the Examiner asserts that the Specification "fails to provide support for flowing an etching gas that consists essentially of C_xF_y, $C_kH_lF_m$, and oxygen, as disclosed in claims 29 – 32." Reconsideration and withdrawal of this ground of objection is respectfully requested in view of the following Remarks.

First, the recitation of "oxygen" appears only in claims 29 and 30, not in claims 31 and 32. Accordingly, this ground of objection should not have been applied to claims 31 and 32. Second, the Examiner's attention is respectfully directed to the paragraph appearing at page 15, lines 1-11 of the original Specification, which teaches that:

"Besides the carbon fluoride, auxiliary gas, and in some embodiments, the CO components, as described above, etching gas compositions in accordance with this invention may further include basic gases (such as a carrier gas) utilized for a common dry etching process (such as O_2), inert gas, etc. Oxygen itself does not etch the oxide layer but can assist the etching action of the carbon fluoride gas and also functions to oxidize and remove by-products generated during the etching process. However, oxygen advantageously etches the photoresist layer, and when the amount of oxygen is too small, a slope is formed at the inner portion of the contact hole to be etched and induces an etch stopping. Considering this point, the preferred volumetric flow rate of oxygen with respect to that of the carbon fluoride gas is about 1:1. As for the inert gas, Ar, He, etc. may be used." (Emphasis added)

The foregoing paragraph makes it clear that the etching gas compositions of this invention may include oxygen, and that they do not always include "the CO components." Additionally, etching gas compositions in accordance with the present invention containing "oxygen" as a component are taught at page 15, lines 17-22; page 16, line 21 to page 17, line 1; page 21, lines 15-18; and in Table 2 at page 22 of the original Specification.

Accordingly, Applicants respectfully submit that the original Specification clearly supports the recitation in claims 29 and 30 of an etching gas composition consisting essentially of a carbon fluoride gas, an auxiliary gas and oxygen.

B. Sec. 112 Rejections

In paragraphs (2) and (3) of the Office Action of September 22, 2004, the Examiner rejected claims 10-13, 15, 16, 18-22 and 29-32 under 35 USC §112, first paragraph as failing to comply with the written description requirement. Reconsideration and withdrawal of each of these grounds of rejection is respectfully requested in view of the following Remarks.

First, the Examiner once again raises the issue of claims 29 and 30 reciting an etching gas composition consisting essentially of a carbon fluoride gas, an auxiliary gas and oxygen. For the same reasons discussed above in section (A) of this Response, Applicants respectfully submit that the original Specification clearly supports the invention embodiments claimed in claims 29 and 30.

Second, the Examiner argues that the "Specification (see page 6, line 19ff) fails to support an etching gas consisting essentially of mixtures of C_4F_6, C_3F_4, C_2F_2...." This argument

is clearly incorrect and should be withdrawn. At page 7, lines 19-21, the original Specification teaches that:

"Particularly, the carbon fluoride gas of the etching gas composition of the present invention includes a double bond or a triple bond, and is at least one gas selected from the group consisting of C_5F_8, C_4F_6, C_3F_4 and C_2F_2." (Emphasis added)

Similar recitations, including the recitation "and mixtures thereof," appeared in original claims 3, 10 and 15.

In claims 31 and 32, Applicants have recited a narrower group of preferred carbon fluoride gases (namely, "C_4F_6, C_3F_4, C_2F_2 and mixtures thereof") useful with the etching compositions of this invention. This narrower Markush group is based on the teaching at page 11, line 3 of the Specification that C_5F_8 gas "is desirable" but is also "expensive." Applicants are clearly entitled to present claims directed to a narrower, preferred embodiment of their invention, particularly where the Specification teaches a reason, in at least some cases, to prefer the narrower embodiment to a broader one as taught by the Specification.

Because the recitations in claims 31 and 32 are fully supported by the original Specification, this §112 rejection must also be withdrawn.

C. Sec. 103 Rejection – Jeng '488 Patent

In paragraphs (5) and (6) of the Office Action of September 22, 2004, the Examiner rejected claims 10 – 13, 29 and 15, 16, 18 – 22, and 30 under 35 USC §103(a) as being

unpatentable over the Jeng '488 patent. Reconsideration and withdrawal of this ground of rejection is respectfully requested in view of the following Remarks.

The Jeng '488 reference is directed to a method for fabricating a semiconductor structure having borderless and self-aligned polysilicon and metal contact landing plugs for providing multilevel interconnections on an integrated circuit board by using successive etch-stop layers to selectively control etching. The description in Jeng '488, as illustrated in Figs. 2 through 12, teaches a "sequence of process steps for making the improved multilevel interconnections by using the borderless self-aligned polysilicon and metal contact landing plugs that prevent the reliability problems of the prior art," (Jeng '488 at col. 4, lines 34-38) (emphasis added).

In order to form the desired multilevel interconnections of the invention, Jeng '488 teaches using a number of different etching compositions at different stages of the process. For example, in connection with the process step associated with Fig. 3, Jeng '488 teaches using "an etchant gas such as trifluoromethane/carbon tetrafluoride/argon/oxygen ($CHF_3/CF_4/Ar/O_2$)," (col. 5, lines 58-61). In a subsequent process step associated with Fig. 6, Jeng '488 teaches using "an etchant gas such as SF_6, CF_4, CHF_3, CH_3F, O_2, and Ar for etching through the polysilicon layer 26, and an etchant gas such as C_4F_8, CHF_3, CH_3F, O_2, Ar for etching the SiO_2 selectively...." (col. 6, lines 50-55). Next, in connection with the process step associated with Fig. 7, Jeng '488 teaches carrying out still another etching step "preferably using an RIE and an etchant gas such as C_4F_8, C_5F_8, CO, O_2, and Ar that selectively etches the SiO_2 layer 22 to the Si_3N_4 layer 20," (col. 6, lines 59-62). Yet another etching step is carried out in connection with Fig. 9 of Jeng '488, where an "anisotropic etching is preferably carried out using an RIE and a

sequence of etchant gases such as CF_4, CHF_3, O_2, and Ar for etching the Si_3N_4 34, and an etchant gas such as Cl_2, SF_6, O_2, and Ar for etching the tungsten layer 32, the barrier layer 30, and the polysilicon layer 26," (col. 7, lines 36-40).

It is only in connection with a final etching step associated with Fig. 11 and only following the complicated sequence of earlier etching steps, that Jeng '488 teaches "using an etchant gas mixture containing fluorine, such as C_5F_8, C_4F_8, CHF_3, CO, O_2, and Ar" to etch the contact holes 8 (col. 7, lines 58-60). This is the portion of Jeng ' 488 referenced by the Examiner. Moreover, in connection with this final etching step, Jeng '488 teaches the use of "self-aligned landing plugs 32B and 32C [to] prevent overetching the contacts in the substrate and etching into the gate electrodes 16, as commonly occurs in the prior art and depicted in FIG. 1" (col. 7, lines 60-64). This teaching clearly suggests that, without "landing plugs 32B and 32C," the contact hole etching process associated with Fig. 11 of Jeng '488 would result in "overetching."

The invention of this application, as presently claimed, differs in numerous ways from the teachings of Jeng '488. First, this invention is not directed to providing a semiconductor device having "multilevel interconnections" as in Jeng '488. By contrast, the principal object of the present invention is to etch contact holes having substantially the same depth (rather than of two different depths) and also having the properties of "having a high aspect ratio and a good vertical profile" (page 1, lines 9-10 of the Specification) such that "the top portion of [each] contact hole...is only very slightly wider than the bottom portion, thereby resulting in a contact hole having a good (desirable) vertical profile" (page 17, lines 1-5 of the Specification). The

present invention does not require the use of "landing plugs" to prevent overetching as in Jeng '488.

To etch contact holes having substantially the same depth, the Applicants have determined that the etching process must be carried out using a particular etching composition which must include a carbon fluoride gas "of the general chemical formula C_xF_y, in which y/x is a ratio having a value less than 2 and which chemical formula includes at least a double or a triple carbon-carbon bond...." At page 10, line 20 – page 12, line 11, in connection with a detailed discussion of Figs. 2A, 2B and 3, the present application discusses a likely technical explanation for the surprising and unexpected phenomenon that the use of an etching gas composition that includes a carbon fluoride gas having at least a double or a triple carbon-carbon bond, in combination with specified proportions of other components, is able to create contact holes having both a high aspect ratio and also a significantly better vertical profile than contact holes formed using conventional techniques, and also without excessive removal of the silicon oxide insulating layer. These differences are clearly illustrated by comparing Fig. 1B of the present application (illustrating the typical result of a prior art etching procedure) with Fig. 4B illustrating the result of an etching carried out in accordance with an embodiment of this invention. Neither Jeng '488 nor any of the other cited prior art teaches or in any way suggests the criticality of selecting a carbon fluoride gas having at least a double or a triple carbon-carbon bond.

The Examiner has argued that "Jeng uses the same etchants in etching the same material to form a contact hole...." (page 5, lines 1-2 of the Office Action of September 22, 2004). But, this statement is not accurate.

At the portion of Jeng '488 referenced by the Examiner (col. 7, lines 46-60 and Fig. 11), Jeng '488 teaches "an etchant gas mixture...such as C_5F_8, C_4F_8, CHF_3, CO, O_2, and Ar," (emphasis added). Claims 29 and 30 of this application, however, recite the use of an etching gas composition which "consists essentially of: (i) a carbon fluoride gas of the general chemical formula C_xF_y, in which y/x is a ratio having a value less than 2 and which chemical formula includes at least a double or a triple carbon-carbon bond...." The C_4F_8, which is a recited component of the Jeng '488 etchant gas mixture referenced by the Examiner, does not satisfy the claim criteria of a y/x ratio having "a value less than 2" or of including "at least a double or a triple carbon-carbon bond." At noted at page 10, lines 20-22 of the application, "C_4F_8 includes only single bonds...."

Under MPEP practice, the claim language "consists essentially of" should be interpreted as excluding from a recited chemical composition any components which would materially alter the properties of the claimed composition. The presence of C_4F_8 in any significant proportion would be expected to materially alter the properties of an etching composition in accordance with the discussion of the theoretical basis for this invention appearing at page 10, line 20 to page 12, line 11 of the Specification. Indeed, it might be the presence of C_4F_8 in the Jeng '488 etching composition that creates the need for using "landing plugs 32B and 32C." Because Jeng '488 fails to teach or suggest the benefits of using only carbon fluoride gas that "includes at least

a double or a triple carbon-carbon bond" as claimed herein, there would be no reason to modify the etchant composition taught by Jeng '488 by reducing or eliminating the recited C_4F_8 component.

In addition, as the Examiner has acknowledged, Jeng '488 fails to teach or suggest the volumetric flow rate ratios of fluorohydrocarbon gas to carbon fluoride gas and of oxygen to carbon fluoride gas as recited in claims 29 and 30.

For all of these reasons, Applicants respectfully request that the Examiner reconsider and withdraw this ground of rejection.

D. Sec. 103 Rejection – Jeng '488 / Chen '822

In paragraph (7) of the Office Action of September 22, 2004, the Examiner rejected claim 18 under 35 USC §103(a) as being unpatentable over the Jeng '488 patent "as applied to claim 29 above" in view of the Chen '822 patent.

The deficiencies of the Jeng '488 reference relative to the present application, and specifically to new claims 29 and 30, have been thoroughly discussed above. Chen '822 does not make up for these fundamental deficiencies. Chen '822 appears to have been cited by the Examiner solely to meet the claim limitation of claim 18 that the "photoresist is a photoresist applicable for DUV wavelength."

Chen '822 is directed to a method for etching sub-quarter micron openings in an insulative layer of a semiconductor device. The Chen '822 method uses a hardmask formed of carbon-enriched titanium nitride which has a high selectivity for etching contact. According to

Chen '822, the high selectivity of the carbon-enriched titanium nitride hardmask makes this process "highly desirable for DUV photolithography."

However, neither Jeng '488 nor the present invention uses a carbon-enriched titanium nitride hardmask as taught by Chen '822. There is no teaching or suggestion of why one skilled in this art would be led to combine the teachings of Chen '822 with those of Jeng '488. Specifically, in what way would the carbon-enriched titanium nitride hardmask of Chen '822 contribute to the realization of the objective of Jeng '488 to prepare a semiconductor structure having multilevel interconnections? Furthermore, even if this combination of references were made, the result would still not be anything remotely approaching the present invention.

Similar to Jeng '488, Chen '822 fails to recognize the criticality of using an etching composition that includes a carbon fluoride gas having at least a double or a triple carbon-carbon bond in order to produce contact holes having a high aspect ratio and a superior vertical profile. The etching compositions taught by Chen '822 use only the conventional carbon fluoride gases such as CF_4, C_2F_6, and C_4F_8 (see col. 4, lines 65-67), perhaps in combination with a fluorohydrocarbon such as CHF_3. But, CF_4, C_2F_6, and C_4F_8 do not satisfy the claim requirements that the ratio of y/x be less than 2 and include at least a double or a triple carbon-carbon bond.

For all of these reasons, Applicants respectfully request that the Examiner reconsider and withdraw this ground of rejection.

E. Allowable Subject Matter

Applicants note with thanks the Examiner's indication that claims 23 – 28 as pending are allowable.

Applicants further note that no prior art rejections were applied to claims 31 and 32. Accordingly, if the Examiner agrees with Applicants' argument in section (B) above concerning the §112 rejection of these claims, then claims 31 and 32 should also be clearly allowable.

Summary and Conclusions

Based on the foregoing arguments, it is respectfully submitted that Claims 10 – 13, 15, 16, and 18 – 32 pending in this application are now in condition for allowance, and such allowance is respectfully requested. If prosecution of the application can be expedited by a telephone conference, the Examiner is invited to call the undersigned at the number given below.

Respectfully submitted,

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